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THE UTILIZATION OF ARPA-SUPPORTED  
RESEARCH FOR INTERNATIONAL SECURITY  
PLANNING

Robert A. Young, et al

Consolidated Analysis Centers, Incorporated

Prepared for:

Advanced Research Projects Agency

October 1972

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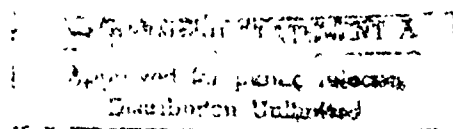
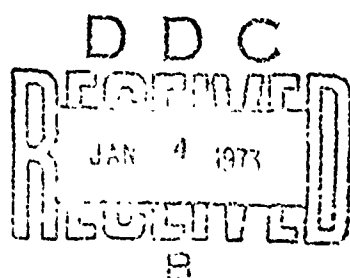
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# THE UTILIZATION OF ARPA - SUPPORTED RESEARCH FOR INTERNATIONAL SECURITY PLANNING

Interim Technical  
Report No. 2  
Appendices  
October 1972



CONSOLIDATED ANALYSIS CENTERS INC.

**C.A.C.I.**

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The study team also wishes to acknowledge the cooperation and support of the six ARPA contractors whose projects were surveyed, the many members of the user community who generously contributed their time and suggestions, and of LTC Austin Kibler and Dr. George Lawrence of the Human Resources Research Office, ARPA.

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## TABLE OF CONTENTS

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	PAGE
INTRODUCTION . . . . .	1
APPENDIX A: PROJECT DESCRIPTIONS . . . . .	2
The Dimensionality of Nations (DON) Project . . . . .	3
The International Data Archive (IDA) . . . . .	11
The World Data Analysis Program (WDAP) . . . . .	17
The World Event/Interaction Survey (WEIS) . . . . .	25
The Cambridge Project (CAM) . . . . .	33
The Center for Computer-Based Behavioral Studies (CCBS) . . . . .	44
APPENDIX B: PROJECT BIBLIOGRAPHIES . . . . .	49
The Dimensionality of Nations (DON) Project . . . . .	50
The International Data Archive (IDA) . . . . .	55
The World Data Analysis Program (WDAP) . . . . .	57
The World Event/Interaction Survey (WEIS) . . . . .	59
The Cambridge Project (CAM) . . . . .	63
The Center for Computer-Based Behavioral Studies (CCBS) . . . . .	65

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## INTRODUCTION

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These appendices are intended as a companion volume to "The Utilization of ARPA-Supported Research for International Security Planning," Interim Technical Report No. 2. The volume's purpose is to make available to members of the National Security Community a general overview of the six ARPA-Supported projects surveyed (Appendix A) and to provide a means whereby potential users of these basic research products can obtain more detailed information on items of specific interest (Appendix B). These overviews of ARPA (Human Resources) supported projects and related research are designed to familiarize and inform potential users of these basic research products. They are not in any way intended as evaluations of the projects.

The six projects reviewed are:

- The Dimensionality of Nations Project (University of Hawaii, Principal Investigator: Rudolph J. Rummel)
- The International Data Archive (University of Michigan, Principal Investigator: Raymond Tanter)
- The World Data Analysis Program (Yale University, Principal Investigator: Bruce M. Russett)
- The World Event/Interaction Survey (University of Southern California, Principal Investigator: Charles A. McClelland)
- The Cambridge Project (M.I. T. and Harvard University, Principal Investigator: J.C.R. Licklider; Director: Douwe Yntema)
- The Center for Computer Based Behavioral Studies (University of California at Los Angeles, Principal Investigator: Gerald H. Shure)

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## APPENDIX A: PROJECT DESCRIPTIONS

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This Appendix presents discussions of the six ARPA-supported research projects listed earlier. Once again, we note that the intention here has not been to evaluate these varied projects, but to summarize their goals and the general thrusts of investigation. The main characteristics of each project are examined, such as project goals, types of data, major analyses and general developments. Also listed for each project are its university location and principal investigator.

## The Dimensionality of Nations Project\*

University of Hawaii

Principal Investigator: R. J. Rummel

### Project Goals

Much of the Dimensionality of Nations (DON) project research is concerned with the relationship between the attributes of nations (or attribute differences between nations) and the international behavior in which they engage. Attributes are descriptors of a nation's political, economic and social system, and include such measures as degree of press freedom, GNP, population size, and population density. The international behavior of nations is described in terms of the amounts and types of international activity which they undertake.

"Behavior" in the DON research often is taken broadly to include not only upper-level official international actions, but also trade, tourist travel, etc. At other times "behavior" refers to some narrower set of international activity, for example, foreign conflict behavior. Research, however, has not been limited only to the relationship of national attributes to international behavior. For example, sources of U. N. voting patterns and effects of different types of conflict resolution efforts in international conflicts have been active research concerns.

### National Attributes as Predictors of National Behavior

DON research into the relationship between attributes and the international activities of nations began when R. J. Rummel employed attribute data and "foreign conflict behavior" data, collected for the year 1955 for 82 nations, in order to test hypotheses which claimed that the attributes of the nations could explain or predict their foreign conflict behaviors. In this test, thirteen types of foreign conflict behavior (e. g., accusations, military action, and expulsion of diplomatic representatives of other nations) were correlated with national attributes such as the level of economic development of a nation and the totalitarianism of a nation's government. The results of the analysis indicated that the attributes of nations were not good predictors of the amounts

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\*Research on this project began in September, 1967. Previous research by DON investigators which is relevant to DON efforts is reported herein.



of foreign conflict behavior in which they engaged.<sup>1</sup> At that time it was speculated that the explanation for the failure to find the expected relationship between attributes and behavior was that the hypothesized relationship had been too simple. The major conclusion from the tests of these hypotheses was that the attributes of a nation would not accurately predict its behavior, but that the differences, or "distances" between nations in their attribute characteristics, might be capable of explaining their behavior toward one another.<sup>2</sup> A simple example of the difference between the original and revised perspective is that whereas the original one might propose that the GNP's of nations can be used to predict the amount of foreign conflict behavior in which they will engage, the revised perspective would suggest that differences in wealth between nations would predict the conflict behavior between them. This perspective, called social field theory, has since been the primary organizing framework of DON research.

#### Identifying Key Variables in the Data

To test the proposed relationship between attribute differences and behavior between nations, decisions were required pertaining to the organization of the attribute and behavior data, since both data sets contained a large number of variables. The DON project often employs factor analysis methods to reduce the large number of variables down to a smaller number of "dimensions" which are more easily analyzed. For example, one factor analysis showed that the percentage of the population involved in agriculture, GNP per capita, telephones per capita, dwellings with running water per capita and other attributes could be usefully measured as one dimension called "Economic Development" with

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<sup>1</sup>R. J. Rummel, "The Relationship Between National Attributes and Foreign Conflict Behavior," Quantitative International Politics, ed. by J. David Singer (New York: The Free Press, 1968), p. 213.

<sup>2</sup>More formally, the new hypothesis was that dyadic behavior (behavior between a pair of nations) is a linear transformation of the attribute distances among nations. Richard Van Atta and R. J. Rummel, "Testing Field Theory on the 1963 Behavior Space of Nations," Research Report No. 43. Prepared in support of Office of Naval Research Contract #N00014-67-A-0387-0003 (University of Hawaii, 1970), p. 19.

little loss of information.<sup>3</sup> Similar analyses on the behavior data show that a single dimension may represent a cluster of similarly varying behavior variables so that it may be more efficient to deal with the dimensions than with each separate variable.<sup>4</sup>

#### Attribute Differences as Predictors of Nation-Pair Relations

Tests of field theory models utilize "dimensions" rather than the large number of variables in the DON data base. These tests have yielded interesting results and a further differentiation within field theory itself. Two tests, one on 1955 attribute and behavior data and the other on similar attribute and behavior data for 1963, are particularly relevant to the research developments on the DON project. In the 1955 test, the field theory hypothesis that behavior between nations is a result of the differences in attributes between nations, and that the relationship would be similar across all pairs of nations, was tested for a large number of nation pairs. The statistic indicating the overall importance of attribute differences in nation-pair behavior was quite low, meaning that the theory seemed to have been rejected when tested against the data. The conclusion was that a modification in the research perspective was necessary in order to achieve more positive results. This modification took the form of a "Model II" of field theory.

#### The Importance of the Policy Environment

"Model II" suggests that for any given nation, attribute differences between itself and other nations will determine the nation-pair behavior patterns, but that the exact nature of the relationship will vary from nation to nation because of uniqueness in each nation's "policy environment."<sup>5</sup> For example, individual decision-making differences may account for the different parameters of each nation.

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<sup>3</sup> Van Atta and Rummel, p. 10.

<sup>4</sup> Gary Oliva and R. J. Rummel, "Foreign Conflict Patterns and Types for 1963," Research Report No. 22. Prepared in support of National Science Foundation Contract No. GS-1230 and Office of Naval Research Contract #N00014-67-A-0387-0003 (University of Hawaii, 1969).

<sup>5</sup> R. J. Rummel, "Field Theory and Indicators of International Behavior," Research Report No. 29. Prepared in support of Office of Naval Research Contract #N00014-67-A-0387-0003 (University of Hawaii, 1969), p. 31.

A test of Model II for the 1955 attribute and behavior data revealed that this perspective was partially upheld by the data, and amounted to a significant improvement over the previous perspectives.<sup>6</sup> The same analyses were performed for the 1963 behavior and attribute data, and the results were nearly identical to those in the 1955 test.<sup>7</sup> An additional study of U.S. behavior toward 81 other nations tended to confirm that the attribute differences between a nation and other nations with whom it interacts can explain at least a moderate proportion of the overall behavior between the nation-pairs.<sup>8</sup>

#### Prediction of Future Nation Behavior

In addition to testing field theory models, the DON project engages in research aimed at predicting the "scores" of nations and nation-pairs on the various behavior "dimensions." Put in a slightly different way, this is an effort to predict the amounts of various types of activity in which nations and pairs of nations engage, including trade, military treaties, negative actions, etc.<sup>9</sup> A specialized technique is used in this process. Tests of this method have resulted in only moderate success.<sup>10</sup> One possible reason suggested for the lack of success was that in these tests large groups of nations and nation-pairs were used, and this tended to obscure the trend patterns of individual

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<sup>6</sup> Rummel, "Field Theory and Indicators of International Behavior," pp. 29-35.

<sup>7</sup> Van Atta and Rummel, pp. 22-35.

<sup>8</sup> R. J. Rummel, "U.S. Foreign Relations: Conflict, Cooperation, and Attribute Distances," Research Report No. 41. Prepared in support of Office of Naval Research Contract #N00014-67-A-0387-0003 (University of Hawaii, 1970), p. 54.

<sup>9</sup> "Prediction" efforts actually have been designed as postdiction attempts, where prediction techniques are used to estimate past data values rather than future values.

<sup>10</sup> R. J. Rummel, "Field Theory and the 1963 Behavior Space of Nations," Research Report No. 44. Prepared in support of Office of Naval Research Contract #N00014-67-A-0387-0003 (University of Hawaii, 1970), p. 24; and Willard D. Keim and R. J. Rummel, "Dynamic Patterns of Nation Conflict 1955 to 1963," Research Report No. 27. Prepared in support of National Science Foundation Contract No. GS-1230 and Office of Naval Research Contract #N00014-67-A-0387-0003 (University of Hawaii, 1969), pp. 14-17.

nations and nation-pairs.<sup>11</sup> Efforts, therefore, may be refined further by a method which will isolate groups of nations which are similar in their behavior trends. Analyses may be undertaken for each group individually in an effort to improve accuracy.<sup>12</sup>

#### Conflict Dynamics and Resolution

Not all of the DON work has taken the same point of view on the role of national attributes in explaining national behavior. In a study of the 1963 conflict behavior of nations, Warren Phillips found that much of the behavior of nations may be explained as responses to the actions of other nations, and that the attributes of nations may play only a secondary role in behavior.<sup>13</sup> He concludes from his research that "...the conflict environment of nations would be expected to have a dynamics of its own with deviations explainable by internal or domestic forces."<sup>14</sup> In another study of conflict dynamics an attempt was made to discover whether particular types of conflict resolution methods (e.g., bilateral negotiations, third party mediation, multilateral conferences, judicial proceedings) predicted the type of outcome of the conflict (e.g., forced submission, acceptance of a new status-quo, non-resolution) in 77 international conflicts that occurred from 1919-1965. The

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<sup>11</sup> Joseph M. Firestone and David McCormick, "An Exploration in Systems Analysis of Domestic Conflict," Research Report No. 24. Prepared in support of Office of Naval Research Contract #N00014-67-A-0387-0003 (University of Hawaii, 1969), p. 69.

<sup>12</sup> R. J. Rummel, "Forecasting International Relations: A Proposed Investigation of Three Mode Factor Analysis," Research Report No. 28. Prepared in support of Office of Naval Research Contract #N00014-67-A-0387-0003 (University of Hawaii, 1970), pp. 26-46.

<sup>13</sup> Warren R. Phillips, "The Conflict Environment of Nations: A Study of Conflict Inputs to Nations in 1963," Research Report No. 42. Prepared in support of Office of Naval Research Contract #N00014-67-A-0387-0003 (University of Hawaii, 1970), pp. 26-46.

<sup>14</sup> Phillips, p. 46.

factor analysis method was used in conjunction with relevant data on these conflicts to determine whether or not there was an association between types of outcomes and types of conflict resolution attempted during the course of the conflicts. The major finding of the research was that types of outcome could not be predicted well from the types of resolution attempted during the course of the conflict.<sup>15</sup>

#### The Relationships of Internal and External Conflict

Two researchers, Raymond Tanter and R. J. Rummel, have investigated the relationship between internal and external conflict.<sup>16</sup> In both the Rummel study and the later Tanter replication of the Rummel study, data were collected for a three-year period. In both studies, only a slight positive relationship was found between the presence of internal conflict, such as coups or anti-governmental demonstrations, and external conflict, such as number of military actions or number of ambassadors expelled or recalled. The findings were in contrast to much theoretical work which preceded the studies.

#### Studies of United Nations Voting

As noted above, factor analysis has been employed to reduce large sets of variables to a smaller number of "dimensions." A similar use of this method has been made in studies of United Nations General Assembly voting. This procedure has led to the identification of a small number of "issue dimensions" which are capable of describing voting patterns in the 69 roll-call votes of the Eighteenth session of the General Assembly.<sup>17</sup> One of these dimensions, titled

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<sup>15</sup> Herbert Hannah, "Some Dimensions of International Conflict Settlement Procedures and Outcomes," Research Report No. 11. Prepared in support of National Science Foundation Contract No. GS-1320 (University of Hawaii, 1968).

<sup>16</sup> Raymond Tanter, "Dimensions of Conflict Within and Between Nations, 1958-60," The Journal of Conflict Resolution (March, 1966), pp. 41-64; R. J. Rummel, "The Dimensions of Conflict Within and Between Nations," General Systems Yearbook, 8 (1963), pp. 1-50.

<sup>17</sup> Richard Pratt and R. J. Rummel, "Issue Dimensions in the 1963 United Nations General Assembly," Research Report No. 21. Prepared in support of National Science Foundation Contract No. GS-1230 and Office of Naval Research Contract #N00014-67-A-0387-003 (University of Hawaii, 1969).

"Cold War," encompassed such matters as the unification of Korea, seating of the People's Republic of China, and the prohibition of nuclear weapons.<sup>18</sup> Taking this issue dimension as a "central issue" in international politics, it was possible to identify groups of nations having similar positions on the issue.<sup>19</sup> Further, by knowing a nation's position on the dimension it may be possible to anticipate its voting pattern on issues related to the dimension. In an effort to add to the explanation of U.N. voting patterns, Jack E. Vincent conducted tests for the relationship between the attributes of nations and their U.N. voting records for the Twenty-Third and Twenty-Fourth General Assembly sessions. In this study a number of significant relationships were found between the attribute dimensions of nations (such as economic development, type of political regime and domestic stability) and their voting records on various issues. For example, it was found that economically developed nations tend to vote negatively on U.N. budget increases, while domestically unstable nations tended to vote favorably on this issue in the 24th session.<sup>20</sup>

A more complicated analysis of these data indicated that 77 measures of national attributes (which were reduced to 13 basic dimensions) were capable of explaining much of the U.N. voting pattern of the 116 U.N. members studied.<sup>21</sup>

#### General Developments

Generally interesting findings of the DON project include the observation that the attributes of a nation (wealth, type of government, etc.) provide fewer clues about how the nation is likely to behave than the attribute

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<sup>18</sup> Pratt and Rummel, p. 9a.

<sup>19</sup> Pratt and Rummel, pp. 2, 18.

<sup>20</sup> Jack E. Vincent, "An Examination of Voting Patterns in the 23rd and 24th Sessions of the General Assembly," Research Report No. 54. Prepared in support of Office of Naval Research Contract #N00014-67-A-0387-0003 (University of Hawaii, 1971), p. 55.

<sup>21</sup> Vincent, p. 25.

differences between the nation and the nations with whom it interacts. Another general finding, which is in agreement with some findings of the WEIS project, is that for many purposes, including prediction, it is useful to deal with groups of nations that are similar in their behavior patterns. Also of note is that the unique policy environment of each nation has shown up in DON research as a possible important factor in national behavior, although at least one other DON study has indicated that the upper-level official political behavior of a nation may be explained largely by how other countries act toward it, with the domestic attributes of the nation being of secondary explanatory importance. The factor analysis method, which has been used extensively in DON research, has been regarded as a useful tool for reducing large quantities of data to fewer dimensions, often with minimal loss of information. The identification of basic "issue dimensions" in U.N. General Assembly voting patterns through factor analysis also demonstrates the potential utility of the method in the realm of anticipating future national positions on international issues.

For further reference to DON research, see the bibliography in Appendix B.

The International Data Archive\*

The University of Michigan

Principal Investigator: Raymond Tanter

Project Goals

The International Data Archive (IDA) places primary emphasis on the development of computer based models, information systems, and instructional packages. The IDA also acquires and maintains international affairs data sets, and stimulates quantitative international affairs data generation.

Conflict Information Systems

The IDA supports development of data set/software packages. Two of these are information systems on conflict: The Computer Aided Conflict Information System (CACIS) and the Computer Aided System for Handling Information on Local Conflicts (CASCON).

While the underlying rationale of CACIS is the systematic search for policy options based on historical precedents, it is not intended to confine alternative strategies of conflict modelling and management to those used in the past. Rather, CACIS is intended (1) to expand the number of usable options and strategies by constructing alternatives based on information from prior conflicts, and (2) to examine alternative futures by applying different models to current and simulated conflicts and evaluating outcomes of the modelling.

One principal attribute of CACIS is that it is being built around four separate but interrelated modules:

1. the memory module which stores information about prior conflicts,
2. the experience module which stores evaluations of strategies used in prior conflicts, and the number of successes, failures, or indeterminate outcomes,

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\*Research under this program began in July, 1969.



3. the involvement module which estimates the type and magnitude of interests (or values) of conflict participants, and
4. the operational environment module which includes external events and domestic political factors. This module could serve as the basis for the evaluation of the relative potencies of internal processes vs. external events on the policy-making process, as well as provide parameters for an all-machine simulation of conflict decision-making.

A second major characteristic of CACIS is its reliance on the process of precedent search. That is, a party to a conflict, in seeking a solution commensurate with its goals, may search for prior conflicts similar to the current conflict as policy guides.<sup>1</sup>

CACIS supplements the Computer-Aided System for Handling Information on Local Conflicts (CASCON), developed by Lincoln Bloomfield and Robert Beattie, and partially supported by the IDA. CASCON focuses on local conflicts between small powers or between a small power and one major power, while CACIS focuses on those conflicts involving more than one major power.

CASCON is intended to serve as an aid to the memory of the decision-maker by bringing before him in rapid and handy fashion pertinent data on past local conflicts. The user of CASCON has on-line access to information on 27 cases of local conflict that have occurred since 1945. Working on an assumption that all local conflicts go through a series of "phases," CASCON presents information related to the extent to which various factors occurring during any of the conflicts have influenced movement to more intense stages. As an aid to the memory of a decision-maker faced with a local conflict,

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<sup>1</sup> Raymond Tanter, "International System and Foreign Policy Approaches: Implications for Conflict Modelling and Management," Theory and Policy in International Relations, ed. by Raymond Tanter and Richard Ullman. (Princeton, New Jersey: Princeton University Press, 1972).

CASCON is intended to be suggestive of policy alternatives and their possible outcomes.<sup>2</sup>

### Computer Aided Instruction

The IDA is developing a Computer Aided International Relations (CAIR) teaching package.<sup>3</sup> CAIR is a set of reading and computer exercise modules designed to acquaint the user with the use of quantitative tools for foreign affairs and cross-national analysis. CAIR consists of three phases. Phase I contains eight substantive modules: introduction and overview, political measurement, bivariate relations (tables), bivariate relations (scatterplots), spurious relationships, controls for bivariate analysis, mathematical interpretation of bivariate relations, and multivariate relations.

The modules contain suggested analytic and statistical exercises and descriptions of appropriate computer software through which the analyses may be performed. The exercises are performed on pre-packaged data sets. At present, three data sets are contained in CAIR; more are being added. Each data set covers some aspect of international affairs.

Phase II will make CAIR available to other institutions.<sup>4</sup> Phase III will include modules on more sophisticated methods such as factor analysis and causal modelling.

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<sup>2</sup> Lincoln Bloomfield and Robert Beattie, "Computers and Policy-Making: The CASCON Experiment," Journal of Conflict Resolution, XI (March, 1971); and Robert R. Beattie and Lincoln P. Bloomfield, "CASCON: Computer-Aided System for Handling Information on Local Conflicts," Summary Report I. Prepared in support of United States Arms Control and Disarmament Agency Contract ACDA/WEC-141 (Massachusetts Institute of Technology, 1969).

<sup>3</sup> Charles Taylor and Raymond Tanter, "The Computer-Aided International Relations Teaching Package," (The University of Michigan, May, 1971).

<sup>4</sup> A partial version of CAIR has been used at the Naval War College, Army War College, Foreign Service Institute, George Washington University, and the Johns Hopkins School of Advanced International Studies.

### International Affairs Data Set Acquisition and Maintenance

The IDA acquires and manages international affairs data sets and collaborates with the International Relations Archive (IRA) in disseminating these data sets. The IDA presently houses 33 major data sets which have been collected by various researchers throughout the country. The IDA sets can be classified as one of four general types: cross-national data (containing information mainly on the social, economic and political attributes of nations), events data (containing political events that occur within and between nations); conflict data (containing information on various attributes of past international conflicts); and international organization data (including informal interaction of U. N. participants, content analysis of General Assembly resolutions, and U. N. roll-call votes).

The following is a sample of types of data contained within the data files.

- Demographic attributes of nations
- Social attributes of nations
- Cultural attributes of nations
- Economic attributes of nations
- Technological attributes of nations
- Political attributes of nations
- Internal political events
- Internal disruption events
- Foreign intervention events
- Economic relations
- Diplomatic relations
- International communications
- Alliance membership
- International organization membership
- International events
- Foreign conflict behavior
- Attributes of conflicts
- Frequency and intensity of war
- United Nations roll-call votes
- Foreign-policy makers' perceptions

The number of nations and time-periods covered by the data sets vary widely.<sup>5</sup>

#### Stimulation of Quantitative International Affairs Data Generation and Modelling

The IDA has undertaken to stimulate international affairs data generation and modelling through the Voluntary International Coordination (VIC) project. VIC has purchased data from important international affairs projects. The following list of VIC purchase order recipients illustrates the type of data generation VIC has stimulated:

Lincoln Bloomfield (MIT) received purchase orders to expand the data base for CASCON (Computer Aided System for Handling Information on Local Conflicts). Patrick McGowan (Syracuse University) received a purchase order for coding foreign affairs actions of 32 African countries between 1964 and 1966. Maurice East (University of Denver) received a purchase order for collecting data on the foreign affairs behavior of 22 nations between 1959 and 1968. Charles Hermann (then at Princeton, now at Ohio State) and Stephen Salmore (Douglass College) together received purchase orders for collecting data on the foreign affairs acts of 14 large nations between 1958 and 1968. Richard Brody (Stanford University) received a purchase order to gather data on major foreign affairs and domestic issues. Michael Sullivan (University of Arizona) obtained a purchase order to gather data on the role of perception during international conflicts. Terrence Hopmann (University of Minnesota) received a purchase order to gather data on international arms control negotiations. William Coplin (Syracuse University) received a purchase order to gather data and develop some indexes covering military disputes involving the World Court, the League of Nations and the United Nations. Allen Whiting (The University of Michigan) received the equivalent of a purchase order to generate data for his study of the use of force by the Chinese Peoples Republic (CPR). Barry Hughes (Case Western Reserve) received a purchase order for two data sets: (1) trade and event interaction

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<sup>5</sup>Data file descriptions which include the time-frame and number of nations in each file may be found in "Data Holdings." Prepared in connection with research supported under Office of Naval Research Contract #N00014-67-A-0181-0026 (The University of Michigan, September, 1971).

among Western European countries 1948 to the present; (2) indicators of elite and mass opinion of relevance to conflict resolution among European nations. Robert North (Stanford University) received a purchase order to derive time-series measures of themes salient to policy-makers through his thematic content analysis of English and German texts. Jeffrey Milstein and John Sullivan (Yale University) received a purchase order to compile data on United States and Soviet aid to and trade with countries in the Middle East, and attribute data on Middle East countries.

#### General Developments

Large quantities of international relations data have been acquired by the International Data Archive. Additional important data sets are being collected and analyzed through the support of the Voluntary International Coordination project of the IDA. Two computerized information systems on conflicts are under development which will serve as aids to the memory of decision-makers and allow analysts to evaluate the effectiveness of policy measures undertaken in past conflicts, thus suggesting policy alternatives and their possible outcomes in new conflict situations. A more general-purpose data set/software package is intended to introduce policy analysts in government agencies and students in general to the use of computers and data for international affairs analysis.

For further reference to IDA research, see the bibliography in Appendix B.

The World Data Analysis Program\*  
Yale University  
Principal Investigator: Bruce M. Russett

Project Goals

The purpose of the Yale project is to collect and analyze data pertaining to patterns and processes of national and international development, conflict and alliance.<sup>1</sup> Research has included efforts to identify forces underlying the creation and maintenance of international alliances, alignments, and milder forms of "diplomatic salience." Alliance is the most formal relation expressed in terms of membership in a formal organization of nations. Alignment is defined by the degree to which nations coordinate their behaviors toward other nations. Diplomatic salience refers to the level of interest one nation has in others, measured in terms of diplomatic personnel exchanged among nations. The effects of alliance upon domestic settings also is a subject of concern, with research initially focusing on domestic consequences of military spending. Studies of national political and economic development and of domestic conflict are additional components of the Yale research project. Research on international conflict processes has focused on the Vietnam war and the Arab-Israeli conflict, and the construction of predictive computer simulation models of these conflict situations. Extensive collections of demographic, economic, educational, cultural, and political data, in addition to data on internal political events for most nations, have been made in support of the research program.<sup>2</sup>

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\* Research under this contract began in September, 1967.

<sup>1</sup> Yale Data Analysis Program, Quarterly Technical Report. Prepared in support of Office of Naval Research Contract #N00014-67-A-0097-0007 (Yale University, 1969).

<sup>2</sup> Many of the over 130 variables collected will be listed in Charles L. Taylor and Michael C. Hudson, World Handbook of Political and Social Indicators, 2nd ed. (Forthcoming, 1972).

## Alliance Studies

In a study of data describing all formal international military alliances during the period 1920-1957, statistical measures were employed to arrive at conclusions regarding the relative effectiveness of various types of alliances. A classification of the alliance into "types" was achieved through a factor analysis of the data. The analysis indicated that the alliances could be grouped according to their "scores" on four "dimensions," each dimension representing a basic characteristic of alliance. The four dimensions by which alliances were grouped concerned the relative dominance of one party in the alliance, the duration of the alliance, the equality of parties to the alliance, and the extent to which the pact was "defensive" in nature.<sup>3</sup> It is suggested in a separate review that such a typology of alliances is highly useful because it allows interpretation of alliance behavior in terms of alliance type.<sup>4</sup> This suggestion is supported by additional findings of the military alliance study; for example, pacts in which nations are roughly equal in power seem more likely to maintain cohesiveness when war breaks out than do pacts which are dominated by a single large power. Another study of formal alliances has attempted to discover predictive relationships between how highly a nation values an alliance and the extent to which it is likely to contribute to the maintenance of the alliance. The results of this study indicated that attempts by larger states to reduce their contributions to the alliance are likely to succeed only when the smaller allies' confidence in the deterrence provided is diminished. The analysis suggested that small states would bear a proportionate or greater-than-proportionate share of military expenditures only if they felt particularly threatened, gained

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<sup>3</sup>Bruce M. Russett, "An Empirical Typology of International Military Alliances," Midwest Journal of Political Science, May, 1971.

<sup>4</sup>John D. Sullivan, "Cooperation in International Politics: Quantitative Perspectives on Formal Alliances," in Behavioral International Relations, ed. by Michael Haas (San Francisco: Chandler Press, forthcoming).

individually some particular benefits from military expenditures, or were coerced to spend more.<sup>5</sup> A study in a related area demonstrated the feasibility of determining the domestic political and economic consequences of changes in national defense spending.<sup>6</sup>

#### Accounting for Alignment and "Diplomatic Saliency" among Nations

Work on alliances has been extended by Yale researchers to include international coordination of a less formal nature. The coordination of international behavior between nations, regardless of any formal arrangements that might underlie such coordination, is termed "alignment." A research project related to this subject attempted to identify some of the forces which give rise to alignment between the United States and other nations.<sup>7</sup> Alignment is measured according to the number of separate actions which the U.S. and another nation direct toward third nations, and the amount of conflict activity which the U.S. and another nation direct to the same nations. The foreign conflict behavior data generated by the Dimensionality of Nations Project were used in this study to measure levels of alignment. Potential explanations of alignment that were investigated included socio-political similarity, trade, propensity to align in the past, and membership in formal alliances. The most significant explanatory variable found was past levels of alignment, suggesting that successful alignment in the past may be a more important determinant of future alignment than any of the other factors considered, including even trade relationships and membership in formal alliances. Levels of trade between nations,

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<sup>5</sup>Bruce M. Russett, What Price Vigilance? The Burdens of National Defense (New Haven: Yale University Press, 1970), Ch. 4.

<sup>6</sup>Bruce M. Russett, "Who Pays for Defense?", Technical Report No. 4. Prepared in support of Office of Naval Research Contract #N00014-67-A-0097-007 (Yale University, 1969).

<sup>7</sup>John D. Sullivan, "The Dimensions of United States Alignments in the Third World." (Paper presented at the International Studies Association Meeting, April, 1970.) Prepared in support of Office of Naval Research Contract #N00014-67-A-0097-0007 (Yale University, 1970).



however, have been shown to be highly related to the "diplomatic salience" between nations. In a study aimed at discovering whether levels of diplomatic salience between countries, measured by the number of diplomatic personnel exchanged, could be predicted from trade levels, socio-cultural similarity, geographical proximity and other factors, factor analysis techniques revealed that trade levels were the best clues to diplomatic salience, apparently outweighing the importance of the other factors.<sup>8</sup> Another study, adding to the evidence that trade and political relations are interdependent, indicated that trading patterns among nations changed more radically between the years 1938 and 1954 than between 1954 and 1963. An explanation offered for this finding is that the political changes that occurred during the earlier period were more significant than those during the later period.<sup>9</sup>

#### Domestic Concerns and Stability

In an illustration of methodology aimed at determining the approaches to economic development and differences among these approaches for three African nations, the General Inquirer content analysis program was used to derive from selected public speeches the attitudes of Ghanaian, Guinean and Tanzanian leaders pertaining to economic development during the period 1956-1969. The output of the content analysis was a series of scores for the nations on such matters as concern with industrialization as opposed to agriculture in economic development.

In the analysis of these scores it was determined that there were some significant differences among the nations in their approaches to development.

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<sup>8</sup>Bruce M. Russett and W. Curtis Lamb, "Global Patterns of Diplomatic Exchange, 1963-1964," Journal of Peace Research, no. 1 (1969), pp. 37-56.

<sup>9</sup>Bruce M. Russett, "Regional Trading Patterns, 1938-63," International Studies Quarterly, XII, no. 4 (December, 1968), pp. 360-379.

For example, Nyerere of Tanzania was found to be significantly more concerned with agriculture in the process of economic development than the leaders of the other two nations.<sup>10</sup> This research indicated that the use of content analysis may contribute to the understanding of the goals and priorities of foreign leaders.

Research on domestic political stability has been concerned both with the forces producing political violence and the consequences of such disorder. In a preliminary effort to isolate forces giving rise to domestic violence and disorder, tests were made for whether conditions such as economic deprivation, low press freedom, and ethnic diversity were associated with domestic political disorder in nations for the years 1960-67.<sup>11</sup> The results of analysis performed on data collected for these variables revealed that population size and level of press freedom emerge as the most significant explanations of riots and demonstrations within nations. Nations with large populations were shown to be more likely to experience domestic turmoil of this type. Nations with very high or very low press freedom experienced little turmoil, while nations with a moderate amount of press freedom tended to experience more turmoil. This finding suggested that nations in which freedom is very scarce are those in which disturbance and protest are kept from occurring, and that nations in which freedom is abundant are those in which the populations have no perceived need to engage in such disturbances.

In a study of the likely results of civil disorder, a research question was framed asking what kinds of civil disruption are most likely to give rise to intervention from foreign nations.<sup>12</sup> Domestic violence and foreign

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<sup>10</sup>Ellen B. Pirro, "Utilization of Content Analysis as a Methodology for Political Science Analysis: Some Illustrations from African Politics," Technical Report No. 5. Prepared in support of Office of Naval Research Contract #N00014-67-A-0097-0007 (University of Minnesota, 1969), pp. 24-25.

<sup>11</sup>Charles Lewis Taylor, "Political Development and Civil Disorder," Technical Report No. 6. Prepared in support of Office of Naval Research Contract #N00014-67-A-0097-0007 (Yale University, 1969), pp. 7-8.

<sup>12</sup>John D. Sullivan, "International Consequences of Domestic Violence: Cross-National Assessment," Technical Report No. 7. Prepared in support of Office of Naval Research Contract #N00014-67-A-0097-0007 (Yale University, 1969)

intervention data for the period 1963-1967 were employed in this analysis. It was found that organized domestic violence, including such measures as unsuccessful attempts at irregular power transfers within nations, were better predictors of foreign intervention than less organized types of domestic violence such as "riots." Further, it was found that organized violence surrounded by uncertainty, measured in terms of the uncertainty of who is in power at a given time, is even more likely to give rise to foreign intervention.<sup>13</sup> Analysis of these data showed that foreign intervention is more likely in countries with a small population and a high international trade dependence on just a few countries. This finding suggested that the country upon which such a nation is dependent may attempt to restore the dependency relationship when the dependent regime is threatened by organized internal disruption.<sup>14</sup>

#### Measurement of International Power Concentration

Included among the factors considered to be important to the Yale research is the general structure of international system power relations. Contributions to the study of power relations have been achieved both through a methodological development for the measurement of international power concentration,<sup>15</sup> and through a substantive study of trends in international power concentration.<sup>16</sup> In the latter study, national power was estimated with population size data for all nations and an index of power concentration was computed for the years 1938 and 1967. The index calculations for the two years, measuring the extent to which power is concentrated in just a few nations, show very little change between the two periods. It was concluded from

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<sup>13</sup>Sullivan, "International Consequences of Domestic Violence: Cross-National Assessment," pp. 10-11.

<sup>14</sup>Sullivan, "International Consequences of Domestic Violence: Cross-National Assessment," pp. 13-14.

<sup>15</sup>Bruce M. Russett, "Probabilism and the Number of Units Affected: Measuring Influence Concentration," American Political Science Review, LXII (1968), pp. 476-480.

<sup>16</sup>Bruce M. Russett, "Is There a Long-Run Trend Toward Concentration in the International System?", Comparative Political Studies, Vol. I, no. 1 (1968), pp. 101-123.

the analysis that there does not appear to be a trend toward greater concentration of power in the hands of just a few nations, at least when power is measured in terms of population size.

#### International Conflict Dynamics

Research on international conflict has aimed at producing operating computer simulation models of conflict situations. Through such models it is possible to manipulate variables to arrive at the consequences of alternative strategies. A simulation model of the Vietnam war has been constructed which is used to forecast likely military responses of one side to the other's actions. The model is based on relationships found in data pertaining to the military activities of all parties in the Vietnam war. The model also produces forecasts of the effects of military activities upon political, economic and social conditions in Vietnam.<sup>17</sup> Data collected for numerous variables in the Arab-Israeli situation, including military clashes between the two sides and U.S. and Soviet military and economic aid to the involved countries, are being analyzed also with the purpose of discovering relationships that might be useful in forecasting. One analysis of these data, which are for the period 1948-1967, attempted to discover whether there has been a relationship between U.S. and Soviet actions regarding the Arab-Israeli conflict and the magnitude of arms spending by the parties involved in that conflict. This study concluded that U.S. and Soviet influence is "limited," and that the Arab-Israeli arms race would likely continue even in the absence of supportive aid from the superpowers.<sup>18</sup>

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<sup>17</sup>Jeffrey S. Milstein, "Forecasting by Computer Simulation: An Aid to Evaluating Foreign Policies in General and Vietnam Policies in Particular," Abstract (Yale University, 1970).

<sup>18</sup>Jeffrey S. Milstein, "Soviet and American Influences on the Arab-Israeli Arms Race: A Quantitative Analysis," Paper presented to the Conference on the Middle East Conflict of the Peace Research Society (International), June, 1970.

## General Developments

Alliance data collections which include such measures as the number of member nations, geographical distance and power equality have proven a useful basis for grouping alliances according to "types." Further research indicates that the behavior of alliances may in some instances be anticipated on the basis of their types; for example, alliance type has been shown to be an important clue to whether or not an alliance will hold together once war breaks out. Conditions under which alliances are likely to remain cohesive when a larger member state seeks to place more of the defense burden on smaller states also have been isolated. Studies of a less formal type of international coordination, alignment, have indicated that successful or rewarding alignment between states in the past may be an important predictor of alignment between the states in the future. Research on the domestic concerns of nations has yielded a method for differentiating among nations in terms of what they view as their most pressing concerns. Studies of domestic violence and turmoil have demonstrated an interesting relationship between "freedom" and turmoil: nations with a very high or a very low level of freedom tend to experience less disorder than do nations in the intermediate range. Research on the international consequences of civil disorder has indicated that foreign intervention is most likely when the nation in which the disorder is occurring is highly dependent economically on one or a few other nations. Large data collections pertaining to specific international conflicts have been compiled and are being employed in an effort to find relationships which will aid in forecasting conflict processes.

For further reference to WDAP research, see the bibliography in Appendix B.

The World Event/Interaction Survey<sup>\*</sup>  
University of Southern California  
Principal Investigator: Charles A. McClelland

Project Goals

The World Event Interaction Survey (WEIS) is engaged in research aimed at uncovering repeating patterns in the interactions among nations, and producing short-term forecasts of these patterns. "Patterns" in interaction refer to enduring predictive relationships between the actions of one country and its subsequent behavior, and other identifiable clues as to the likely future actions of nations. WEIS research therefore is concerned with such questions as whether increased hostility between the Arab states and Israel will result in greater cooperation among the Arab nations; whether an increasing trend in Mideast conflict will continue, and what the future may look like if it does; whether there are identifiable clues to imminent crisis or conflict among nations.

The WEIS Data

The research applies advanced data analysis techniques to the WEIS data base which consists of a record of the actions engaged in (from January 1966 to the present) by each nation in the international system. Important actions which are international in character are collected on a daily basis from the New York Times and stored in a large computer file which presently contains more than 40,000 of these actions. An action is "important" if its source is an upper level government official or spokesman; it is "international" if it is aimed toward some other nation or international body. A USSR threat issued to the United States or a request made by Israel to the United Nations are examples of the types of actions contained in the WEIS data base. Two major WEIS files are maintained in computerized form. An "analytic" file consists of coded

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<sup>\*</sup>Research on this project began in September, 1967. Previous research by WEIS investigators which is relevant to WEIS efforts is reported herein.

records of the actions. Actions are coded as belonging to one of 63 categories of action<sup>1</sup> and stored with other coded information identifying the acting nation, the nation to whom the action was addressed, and the date of the action. Another file contains the same actions but not in a coded version. This file consists of one-sentence prose descriptions of each action and is therefore called the "descriptive" file. Both files contain all of the actions collected from the New York Times since the beginning of 1966, and are updated each month as new data become available.

### Information Retrieval

Subsets of the coded data may be organized and retrieved through a specially developed computer program, "WEISUM." For example, one research problem may call for an organization of the data which separates the "verbal" actions of a nation (e. g. , promises) from the actual "deeds" which it has performed (e. g. , granting economic aid). Another research problem may suggest a division of a nation's actions into co-operative and conflict types. More specialized concepts, such as "defensive verbal conflict", also may be defined, and the large data file sifted for the events which represent this type of behavior.<sup>2</sup> Furthermore, selected types of actions may be retrieved for any nation or group of nations, on a daily basis or a more aggregated basis, and for selected nations who are the "targets" of actions taken by other nations.

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<sup>1</sup> A detailed description of the coding procedures may be found in Barbara Fitzsimmons et al. , "World Event/Interaction Survey Handbook and Codebook," Technical Report #1. Prepared in Support of Office of Naval Research Contract #N000014-67-A-0269-0004 (University of Southern California, 1969).

<sup>2</sup> Charles A. McClelland and Robert A. Young, "The Flow of International Events, July-December, 1969," Interim Technical Report. Prepared in support of Office of Naval Research Contract #N000014-67-A-0269-0004 (University of Southern California, 1970), p. 13.

A multi-file data management system based on IBM's Generalized Information System (GIS) has been implemented to handle the storage and retrieval of WEIS data. The system allows the user to enter data through a terminal to be stored in the master file. Built-in procedures allow automatic checking for errors in the data before they are transferred to the permanent file, and allow the creation of subfiles with only a few simple commands. In addition, the system has a capability to search the data for relevant information desired by the user. The original WEIS analytic and descriptive files have been merged into a single file, so that the user can type in a few codes or keywords on the terminal, such as MIDDLE EAST or WARN and retrieve all events containing these symbols.<sup>3</sup>

#### Monitoring International Actions

An early discovery in the analysis of coded international actions was that certain measures of nation behavior may be "sensitive indicators," or clues, to the beginning and subsequent stages of crises. This finding was derived through the use of an "information" measure which measures the extent to which the international actions of a nation differ from a normal pattern. A major finding of this work was that in a series of Berlin and Quemoy crises the measure proved highly sensitive as a clue to the onset of crisis, suggesting that the beginnings of crises are characterized by a tendency toward searching, almost random behavior among the involved parties.<sup>4</sup>

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<sup>3</sup> Charles A. McClelland, et al. "The Management and Analysis of International Event Data: A Computerized System for Monitoring and Projecting Event Flows," pp. 34-65. Prepared in support of Office of Naval Research Contract #N00014-67-A-0269-0004 (University of Southern California, 1971.)

<sup>4</sup> Charles A. McClelland, "The Beginning, Duration and Abatement of International Crises: Comparisons in Two Conflict Arenas," International Crises: Sources and Consequences. New York: Free Press (forthcoming).



WEIS researchers pursued the development of measurements of coded data which could provide clues to the likelihood of crisis or conflict between pairs of nations. These measurements utilize the WEIS data base to identify trends in the amounts and types of actions which might indicate that a crisis or conflict is approaching. The development of indicators of oncoming crisis includes an attempt to measure statistically the extent to which the interactions among nations are becoming "unusual," both in terms of quantities and types of events. "Unusual" activity is defined and measured statistically in terms of changes in behavior from a previous normal configuration. Studies of both the Middle East crisis of 1967 and the recent Czechoslovakian crisis have revealed that such measures do provide warning in advance of the actual outbreak of crisis.<sup>5</sup>

WEIS researchers have developed a WEIS Processor to monitor the flow of international events. The purpose of this monitoring process is to identify any deviations in behavior of a given nation from past behavior patterns. The user may obtain information by using several simple computer routines to compare newly entered data to past data already stored in a permanent file. These routines enable the user to obtain information about any unusual changes in the number of actions taken by a nation or any changes in the variety of actions by a nation. The user can obtain these types of information in descriptive, analytic, or graphic display form. In this way, he can identify any unusual patterns that may emerge and look for further clues to basic behavior changes.<sup>6</sup>

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<sup>5</sup>Gary D. Hoggard, "Indicators of International Interaction," Paper presented at the 65th annual meeting of the American Political Science Association, New York, September, 1969.

<sup>6</sup>McClelland, et al., "The Management and Analysis of International Event Data," pp. 88-178.

### Computer Simulation

WEIS researchers have investigated the uses of probability-based computer simulation models. The purpose of this activity is to synthesize the indicators of behavior used in event analysis. Computer simulation provides a method for modelling nation behavior using the information received from the WEIS processor monitoring system. Simulation models can provide theoretical clues to changes in patterns of nation behavior, thus providing the basis for the prediction of changing relationships, and particularly for forecasting conflicts or crises. The first attempts at model construction enables the analysts to generate probabilities of USA-USSR behavior, in terms of amount of behavior and variety of activities, from past records of USA-USSR event/interactions.<sup>7</sup>

### Prediction: Effects of Alternate Courses of Action

Exploration for patterns and predictive relationships in the WEIS data has involved application of a broad spectrum of concepts and data analysis methods. Some of this research has focused upon the behavior of nations during periods of crisis or conflict. This research has attempted to delineate recurring patterns of behavior during such periods, eventually to allow a generalization of findings and a basis for anticipation of likely processes and outcomes when new crises or conflicts occur.<sup>8</sup> An early study explored a number of hypotheses about conflict by testing these hypotheses against sixteen separate international conflicts. An example finding from this study is that when minor injury or property destruction

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<sup>7</sup> McClelland, et al., "The Management and Analysis of International Event Data," pp. 337-374.

<sup>8</sup> Charles A. McClelland, "International Interaction Analysis; Basic Research and Some Practical Applications," Technical Report #2. Prepared in support of Office of Naval Research Contract N000014-67-A-0269-004 (University of Southern California, 1968).

occurs early in a conflict, there is a high probability that major violence will follow.<sup>9</sup> Such extensive studies of conflict have been supplemented by intensive studies of just one or a few conflicts. A study of the actions of nations involved in the Vietnam war revealed, for example, that the Vietnam conflict did not result in a shift of U.S. behavior and attention away from Europe to the Pacific in its earlier stages. This suggests that major powers such as the U.S. might be predicted to maintain a regular flow of relations with other nations even while becoming involved in an unusual and consuming situation elsewhere.<sup>10</sup> The Vietnam study also concluded, from an analysis of Soviet and Chinese interactions, that the escalation of the war did not produce a growth of unity, as measured by the number of cooperative actions, between the two socialist powers, and that in fact the "gap" between the two, measured by conflictual actions, widened during this period.<sup>11</sup> This finding may be contrasted to one produced from an analysis of recent event patterns in the Middle East. The Middle East study found support for the proposition that increases in Arab-Israeli military actions produced a tendency for greater cooperative actions among the Arab nations.<sup>12</sup> Taken together, the Middle East and Vietnam studies have indicated that the relative involvement in a conflict of nations advocating a generally similar position may be an important consideration in predicting the effect of the conflict on the unity of these parties.

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<sup>9</sup> Barbara J. Fitzsimmons, "The Role of Violence in International Conflicts," Support Study #1. Prepared in support of Office of Naval Research Contract N000014-67-A-0269-0004 (University of Southern California, 1969), p. 53.

<sup>10</sup> Martin J. Miller and Harold Meinheit, "Behavioral Interaction in the Vietnam War, 1965 and 1966," (University of Southern California, 1968), p. 33.

<sup>11</sup> Miller and Meinheit, p. 33.

<sup>12</sup> Charles A. McClelland and Anne Ancoli, "An Interaction Survey of the Middle East," (University of Southern California, 1967), p. 20.

Other prediction efforts have attempted to specify a methodology and framework capable of extrapolating existing trends in relationships and answering "what if" questions about the future. For example, one research problem required a forecast of Israeli-UAR interactions, in addition to forecasts for other nations and nation pairs, for a particular month in 1969. Two methods, among others, were employed in this effort. The first method involved the calculation of a trend in Israeli-UAR interactions by an application of regression methods to the previous history of interactions (as contained in the WEIS data) between the two nations. This method produces a trend equation, expressing past trends in interaction, which is used to forecast future levels and types of interaction. The second method utilized regression techniques to discover the relationship between the actions of Israel toward the UAR and the actions of the UAR toward Israel. This method allows prediction of one side's actions when the other side's actions are known and allows one to specify the likely outcomes of alternate choices of action.<sup>13</sup> This research indicates that appropriate predictive methods may vary from nation to nation, or among pairs of nations. Therefore, an extension of this effort is a taxonomy of nations based on their international behavior characteristics as measured by the WEIS analytic data. Factor analysis and related methods which are used to group entities according to their similarities were used to derive this taxonomy.<sup>14</sup> Forecasting efforts also indicated that more sophisticated "time-series" methods capable of

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<sup>13</sup>James A. Moore and Robert A. Young, "Some Preliminary Short-Term Predictions of International Interaction," Working Paper #1. Prepared in support of Office of Naval Research Contract #N000014-67-A-0269-0004 (University of Southern California, 1969).

<sup>14</sup>Robert A. Young, "Prediction and Forecasting in International Relations: An Exploratory Analysis" (Unpublished Ph. D. dissertation, University of Southern California, 1970).

detecting cyclical trends and predictive relationships also should be employed. For this reason time-series methods with these capabilities have been investigated.<sup>15</sup>

### General Developments

Among the most general findings of WEIS project research are those suggesting that sensitive indicators or "clues" to possible crisis or conflict between nations are identifiable through a quantitative approach to international interaction. Research also has indicated the presence of uniformities across many cases of conflict and crisis. Such uniformities may provide information which will be useful in attempts to anticipate likely processes and outcomes of conflicts. Prediction attempts have demonstrated the feasibility of projecting trends in international activity and asking "what if" questions with quantitative behavior data, and it has been indicated that the appropriate predictive methods may vary from nation to nation. Follow-up research on this indication has demonstrated the possibility of grouping nations according to their international behavior patterns. The continuous monitoring and prediction effort now underway should provide additional insights into these research problems. In the area of information retrieval, WEIS has created and adapted computer programs which are capable of retrieving summaries of international events according to a wide range of selection criteria.

For further reference to WEIS research, see the bibliography in Appendix B.

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<sup>15</sup> Gary A. Hill and Fred Ebrahimi, "Multi-Channel Time Series Analysis: An Introduction to Analysis for International Event Prediction, "Support Study #5. Prepared in support of Office of Naval Research Contract #N000014-67-A-0269-0004 (University of Southern California, 1970).

The Cambridge Project  
M. I. T. and Harvard University  
Principal Investigator: J.C.R. Licklider  
Director: Douwe Yntema

Project Goals

The Cambridge Project is a cooperative effort among researchers at M. I. T. and Harvard to develop techniques to facilitate the use of computers in behavioral science. The Project has two goals. The first is to provide both methodology and accompanying computer software that would be generally useful to behavioral scientists. The research programs with this as their goal are classified as related to either data-handling, data analysis, modelling or experimental laboratory procedures. Numerous developmental efforts are included under each of these categories.<sup>1</sup> The second goal is to combine those developments into an integrated system of computing tools for use by behavioral scientists.<sup>2</sup>

Data-Handling

The development of procedures for data-handling is intended to aid the researcher in preparing, storing and managing his data. The purpose of these developmental programs is to reduce the time spent by the researcher in the organization of his data for analysis on computer. The researcher with a large amount of data must spend much time and effort organizing his data before he begins his analysis. Sometimes he may want to extract a certain set of data from a data file already on the machine.

The Cambridge Project includes many varied efforts at data-handling. These attempts are aimed at helping the user in the storage, manipulation

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<sup>1</sup> The Cambridge Project, Annual Report: June 1969-June 1970. Prepared in support of DSSW Contract DAHCl5-69-C-0347 (M.I.T., 1970), pp. 15-23. (Note that the 1969-1970 Annual Report is hereafter referred to as Annual Report. The later 1970-1971 Annual Report is referred to as Annual Report: June 1970-1971 throughout.)

<sup>2</sup> Annual Report, pp. 9-14.

errors, and produces graphic displays of the data. It can be linked to many computer facilities and has been used by state and local agencies and city governments to handle large amounts of complex data.<sup>6</sup>

A developmental program in the handling of textual materials is the Technical Information Project (TIP). The project has designed an information system which allows the user to scan a set of data at a remote terminal and ask the computer to select specific items by searching the data for key words and key words-in-context. A package of text-handling procedures has been completed to aid the user in handling textual information on the machine.<sup>7</sup>

#### Data Analysis

The project includes the development and evaluation of four types of data analysis tools. The numerous programs are classified as related to either multidimensional scaling and analysis of multivariate data; analysis of networks; time-series and sequential analysis; or analysis of natural text.<sup>8</sup> More general methodological work also is being undertaken, including the application of several methods of analysis to the same sets of data in order to learn to what extent substantive conclusions differ as the result of decisions about methodology.<sup>9</sup>

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<sup>6</sup> The principal researchers in this program are Aaron Fleisher and Wren McMains. For a description, see "EFFECT," Annual Report, pp. 36-37.

<sup>7</sup> This project is directed by Meyer M. Kessler and William D. Matthews. For a description, see "Components and Subsystems for Handling Text," Annual Report: June 1970 - June 1971, pp. 2-8 through 2-13.

<sup>8</sup> Annual Report, pp. 18-20.

<sup>9</sup> The principal researcher in one such program is Rosemarie Rogers. For a description, see "Comparison of Different Data Analysis Techniques and Programs," Annual Report, pp. 45-46.

Multivariate statistical methods are required to test complex social theories involving data bases with many variables. The Cambridge Project involves a number of efforts to facilitate and extend the capabilities of multivariate analysis. One is the development and refinement of a multidimensional clustering program for social science data. Basically, the purpose of the program is to discover groups of objects that are similar to each other.<sup>10</sup> For example, the user may be studying a large group of trainees, for each of whom a number of measures (e.g., test scores) are available. He may use the program to group the trainees into clusters within each of which all of the people have similar scores.

Another kind of analysis, "network analysis," is common to many fields. A broad spectrum of relationships, including international trade flows, patterns of friendship and of commuter traffic can be represented as networks. A major project in the analysis of networks is the work of Karl Deutsch and his colleagues in the analysis of transaction networks. Two computer programs have been developed and used to analyze trade flows among nations. The first program, RANULL, allows the researcher to analyze transaction flows (e.g., trade), communication networks, and attention patterns among nations. The program is an aid to the identification of patterns in a network.<sup>11</sup> Work is under way to employ these methods in the study of political integration.<sup>12</sup> The second

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<sup>10</sup> Fred L. Bookstein, "A Note on a New Algorithm for Multidimensional Clustering," (M.I.T., 1970).

<sup>11</sup> A discussion of the technical aspects of RANULL may be found in Carey A. Mann and Richard W. Chadwick, "RANULL: A Transaction Flow Analysis Program," (M.I.T., 1971).

<sup>12</sup> Richard W. Chadwick, "Steps Toward a Probabilistic Theory of Political Behavior, with Special Reference to Integration Theory," Paper presented at the meeting of the International Political Science Association, Munich, Germany, 1970.



program, DICHOT, is intended to provide additional methods of finding patterns in network data.<sup>13</sup>

The third type of data analysis is the analysis of data over time. The social sciences, it is often pointed out, tend to emphasize cross-sectional studies at one point in time to the exclusion of cross-time, or time-series, analysis. Most time-series tools were developed to serve fields such as economics, whose data are quite different from some behavioral science data. Developmental work in time-series for the behavioral sciences is intended to overcome some of the difficulties in applying time-series methods to behavioral science problems. Work in this area includes the development of time-series methods for application to slowly varying processes and for the analysis of processes for which only sparse data are available.<sup>14</sup>

A related project in this area is an attempt by Allan J. Lichtman and Frank Friedel to integrate "computer-aided quantitative analysis and the traditional methods of the historian" using electoral and census data. The project aims at the construction of time-series and causal models of changes in political behavior.<sup>15</sup>

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<sup>13</sup>A detailed explanation of the technical aspects of this program may be found in Richard W. Chadwick, "DICHOT: A Program for Hierarchical Dichotomization of Matrices, Based Upon the McQuitty-Clark Method of Iterative Intercolumnar Correlations," (M.I. T., 1971).

<sup>14</sup>The specific programs are "Bayesian Analysis of Slowly Varying Non-Stationary Processes," principal investigator Colin C. Blaydons; and "An Analysis of Sparse Demographic Time-Series," principal investigator Maris A. Vinovskis, Annual Report, p. 48.

<sup>15</sup>For a description see "Causal Relationships and Temporal Changes in Political Behavior," Annual Report, p. 48.

A fourth area of research in data-analysis is the development of tools for the analysis of textual material. The Cambridge Project Annual Report points out that a large amount of potentially valuable information is found in written documents such as speeches or committee reports. The development and evaluation of programs to extract information from documents is a major effort to aid the behavioral science researcher.<sup>16</sup>

An important development in the analysis of textual material is the General Inquirer III system for computer content analysis. This new system allows the analysis of words in context so that the actual "sense" of the word or phrase may be determined by the researcher. Three dictionaries are being prepared for use on the computer: a general purpose social science research dictionary developed by D. C. Dunphy; a dictionary concerned with the language people use to describe themselves and others in sentence completion formats developed by C. Gordon, M. Zavalloni and Robin Chard; and an updated version of the Lasswell-Namenwirth value analysis dictionary for political science analysis, adapted by Zvi Namenwirth. The new system will be available on the timeshares Multics system at M.I.T. and in the PL/I language on larger IBM 360 systems at a considerably reduced cost to the user.<sup>17</sup>

Another effort in the analysis of natural text is a project to develop a method for extracting information about themes of documents. The researchers selected newspaper editorials, commentaries and news items from the United States, Britain, and the Soviet Union to be

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<sup>16</sup>Annual Report, pp. 19-20.

<sup>17</sup>See Edward F. Kelly, Greg H. Heil, and Philip J. Stone, "New Resources in Computer Aided Content Analysis of Natural Text," Paper submitted for the Second International Joint Conference on Artificial Intelligence, Imperial College, London, September, 1971; "An Announcement Concerning Inquirer III," (Harvard, 1971); and "An Inquirer III Content Analysis System," principal investigator Philip J. Stone, Annual Report, pp. 52-55.

processed first through an extracting program and then through a more sensitive analysis of the extracted text to detect themes in the documents. The method is expected to greatly reduce the cost of this type of analysis.<sup>18</sup>

### Modelling

The construction of models is useful in both basic research and practical applications. Models allow the researcher to specify theoretical or observed relationships in the behavior of a system which he wishes to study. Such models may be employed in attempts to predict future behavior of one or more aspects of the modeled system.<sup>19</sup>

Research in the field of modelling includes a series of efforts aimed at creating the capability to construct, test and revise social science models on-line. On-line capability, which refers to analysis from a teletype or similar terminal, is desirable because the construction and testing of models often is a process of trial and error, requiring that the model-builder be able to experiment in a continuous fashion with his data and models. First tests of a system designed for this purpose have involved attempts to model, on-line, the competitive acquisitions of military hardware by less-developed nations.<sup>20</sup> Other work in the area of modelling involves the development of methodology for the evaluation

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<sup>18</sup> The principal investigators of this project are Rosemarie Rogers and William E. Griffith. For a description see "Development of Computer-Based Methods for Identifying Themes in Documents," Annual Report, pp. 51-52.

<sup>19</sup> Annual Report, pp. 20-22.

<sup>20</sup> The principal investigator of this program is Amelia C. Leiss. For a description see "An Exploratory Attempt to Build and Validate a Complex Model with Existing On-Line Facilities," Annual Report, pp. 59-60.

of simulation models and includes methodological refinements in model validation methods.<sup>21</sup>

One of the programs in the modelling area is intended to provide social scientists with tools for making decisions. The program helps the user to resolve ambiguities, enables him to make specific decisions or to study the decision process by assessing the probabilistic values of variables he wishes to consider.<sup>22</sup> Another task tests alternative models of nation-behavior against time-series data on attributes and capabilities of individual nations. This program examines problems of model validity in three areas: how the parameters of the model change through time; how sensitive the parameters are to changes in the unit of analysis; and how sensitive the parameters are to specific properties of the data base.<sup>23</sup>

#### Control of Experiments

A final series of projects involves the development of computer facilities for experimental research. These facilities can be used in laboratory experiments and in various types of simulations and games.<sup>24</sup>

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<sup>21</sup>The principal investigator of this program is Richard L. Nolan. For a description see "Methodology for Evaluation of Simulation Models," Annual Report, pp. 60-62. See also "Simulation Techniques for Small Geographic Areas," Annual Report, pp. 38-41.

<sup>22</sup>The principal investigators of this program are Zenon S. Zannetos, Michael S. Scott-Morton, John F. Rockart, and George T. Dixon. For a description see "Tools for Probabilistic Models," Annual Report: June 1970-June 1971, pp. 4-6 through 4-7.

<sup>23</sup>The principal investigator of this program is Nazli Choucri. For a description see "Validation in Multivariate Time Series Analysis," Annual Report: June 1970-June 1971, pp. 4-8 through 4-9.

<sup>24</sup>Annual Report, pp. 22-23.

One of the efforts in this area is an attempt to create an "information-trapping system" to allow researchers to observe and record the communications of participants in a simulation. A Harvard Business School game, based on a competitive market model, was used to experiment with the development of the system. At present, the capability exists to record information used by decision-makers interacting with the computer and to analyze on the computer actual decisions of the players. A general aim is to gain insights into the type of information the individual chooses and the way in which he relies on the computer system with which he interacts, so that ways of improving the computer system for information-handling in a simulation with a large number of participants may be determined.<sup>25</sup>

#### The Consistent System

Ultimately, the developments described above, and others of a similar nature, are to be combined into an integrated system of tools for use in the behavioral sciences, both basic and applied. This is to be a system of data, models, and programs for on-line, interactive use by researchers who are not programmers. Programs are to be compatible with data and with other programs so that a non-programmer can combine them in whatever way his research seems to demand, even though they may have been intended for different branches of behavioral science. An exploratory version of an integrated system, known as Toss, is currently available for experimental use within the Multics time-sharing system at M.I.T.<sup>26</sup>

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<sup>25</sup>The principal investigators of this program are John Bishop, Neil C. Churchill, F. Warren McFarlan, James L. McKenney, Howard W. Pifer and Lewis B. Ward. For a description see "Information, Structure and Decision-Making in A Complex Environment," Annual Report, pp. 74-75.

<sup>26</sup>"Toss: An Exploratory Foundation for an Integrated Program," Annual Report, pp. 77-80.

and handling of numerical and textual materials. Three of the major data handling projects involving quantitative data are the Admins Mark III system, the Multics Social Science System, and EFFECT.

The Admins Mark III System is a set of interactive programs designed to aid the user in the detection and correction of error in his data and in the arrangement of the data into the proper form for analysis by the computer.<sup>3</sup> The system is capable of performing statistical computations including multivariate correlation, regression and factor analysis. The Admins programs may be accessed through a remote terminal.<sup>4</sup>

The Multics Social Science System deals with data-management and analysis problems frequently encountered in the behavioral sciences. The system allows a user to choose his own levels of sophistication in the operation of the system. In addition, a Multics On-Line Table Statistics (MOTS) system has been designed to train social scientists to do statistical analysis through the computer. MOTS acquires data from the terminal, creates cross-tabulation and display tables, stores them, and retrieves them for later display.<sup>5</sup> Both Admins and the Multics system projects are continuing to develop new programs as aids to the researcher.

The third project, EFFECT, is designed to manage large data files at low cost to the user. With only a few minutes of instruction, the user can perform operations on a large data set. EFFECT allows the researcher to make transformations in his data so that there are fewer

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<sup>3</sup>The principal researcher in this program is Stuart McIntosh. For a description, see "Additions to Admins Mark III," Annual Report, p. 47.

<sup>4</sup>Other types of analysis available on the Admins system are discussed in Roy Hofheinz, Jr., "Cross-Model: An Interactive Multivariate Analyzer for Admins," (Harvard University, 1970).

<sup>5</sup>Many Cambridge Project programs use Multics. The principal researchers in the program are Allan Kessler, Jeffrey Stamen and Ithiel de Sola Pool. For a description, see "Multics Social Science System," Annual Report, p. 56.

### General Developments

The research of the Cambridge Project is primarily developmental and experimental. Many of the programs are already available to interested users. Continuous evaluation of and additions to the projects are being made. The various programs have developed new capabilities for data-handling, analysis, modelling and experimental control for the behavioral sciences. In the area of data-handling, new techniques have been designed to aid the inexperienced researcher in the storage and management of his data on computer. Data analysis projects have developed programs to analyze large, complex data sets, and different types of networks. Techniques have been developed to aid in the analysis of data over time and to reduce the complex problems and high cost to the user in the analysis of textual material. Modelling efforts are being made to design and evaluate theoretical models and simulations at a remote computer terminal. Efforts at controlling laboratory experiments, simulations and games by computer are underway. The methodology and computer programs are intended for use by a diverse community of behavioral scientists. Ultimately, techniques of all these kinds are to be combined into an integrated system for interactive use by non-programmers.<sup>27</sup>

For further reference to Cambridge Project research, see the bibliography in Appendix B.

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<sup>27</sup> For a detailed description of the plans for a "Consistent System" see Section 6 of the Cambridge Project's latest Annual Report: June 1970-June 1971.

The Center for Computer-Based Behavioral Studies\*

University of California at Los Angeles

Principal Investigator: Gerald H. Shure

Project Goals

The Center for Computer-Based Behavioral Studies (CCBS) at UCLA is designed to pursue a broad range of developments for laboratory experimentation, gaming and simulation, and for more powerful analysis of behavioral data derived from laboratory experimentation, simulation, and data archives. CCBS applications of these developments mainly are in the area of international relations studies, including analysis of negotiation and crisis behavior in experimental gaming. The Center's work roughly may be divided into specification and integration of computer hardware, system software development, data management and analysis, and experimental studies of behavior in a laboratory gaming environment.

Specification and Integration of Hardware Development

The computer hardware developments undertaken by the Center are intended to serve a variety of functions.<sup>1</sup> A large-scale time-shared computer system, including a PDP-10 computer, a PDP-15 computer, 24 computer terminals, and peripheral equipment are being integrated. A hardware/software system to provide virtual memory is also being developed.

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\*Research on this project began in July, 1969. Previous research of CCBS investigators which is relevant to CCBS efforts is reported herein.

<sup>1</sup> For a more complete description of CCBS hardware, see "Center for Computer-Based Behavioral Studies," Technical Report. Prepared in support of Rome Air Development Center Contract No. F30602-70-C-0016 (University of California, Los Angeles, 1970), pp. 8-13.



## System Software Development

The PDP-10 timesharing monitor interacts with high-speed terminals and a high-speed printer and plotter to allocate computer resources to several simultaneous uses. In the utilities area, improved capabilities for on-line editing of computer-stored files and formatting of documents are under development. Special compilers are being implemented to allow programming in two higher-order programming languages, an extension of the META6 metacompiler and an extension of the JOVIAL programming language.<sup>2</sup>

## Laboratory Support for Gaming and Simulation Studies

Computer-based laboratory capabilities provide for automatic on-line administration, control, monitoring, and recording of decision-making behavior of participants in multi-person gaming exercises, and the reduction of these data for later analysis. Experimental subjects also may be given access to data relevant to their decisions through a terminal linkup with stored data files. Data sets may include "real world" data relevant to the current experimental problem or simulation. Work currently is underway to simplify the use of these facilities for experimenters who have little or no understanding of computer technology. This work entails the development of a "Laboratory Implementation System" which will ease the translation of the researcher's experimental specifications into computer terminology.<sup>3</sup>

## Data Management and Analysis

The emphasis in data management and analysis is the development of software tools that increase the efficiency with which standard, and more

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<sup>2</sup> System software is more fully described in Technical Report, pp. 13-20.

<sup>3</sup> The Laboratory Implementation System is described in Robert J. Meeker, Gerald H. Shure, and Alvin S. Cooperband, "An Implementation System for Designing a Computer-based Experiment" (University of California, Los Angeles, 1971).

particularly, unique data analyses may be undertaken. The analyst, through the computer terminal, is capable of directly interacting with data in an experimental fashion, searching for explanatory relationships in his data. This capability is provided by two software innovations, TRACE and IDEA, which are undergoing further development at CCBS. As the discussion below illustrates, these two software packages are intended to augment the analyst's data-manipulation and data-analysis capabilities by providing him with on-line access to flexible data-manipulation and data-analysis programs.

TRACE is comprised of a set of data manipulation, display, and analysis programs for behavioral data. It is operated through a simple but powerful command language requiring little or no programming experience on the part of the user. One of its major features is its ability to partition, nest, aggregate, and group data in any way the user specifies, even if the original sets are not immediately compatible. The TRACE system will prompt the analyst until he has fully specified the nature of his manipulations or derivations of new variables he desired to create from the data, and will then create the user-specified data set and save it as a computer file, maintaining necessary associations with previous data for later analysis or display. The system has been found highly useful in reducing the difficulty and time involved in "sharpening and improving" the organization of data sets.<sup>4</sup> An advanced version, TRACE III, is being developed at CCBS. Improvements in the system's capabilities to combine indices from separate data sheets, to produce summary statistics and data displays, and to efficiently update data files are under development. Hardware developments designed to reduce the cost of operating TRACE on very large data bases are also underway.

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<sup>4</sup>TRACE is described in Gerald H. Shure, Robert J. Meeker, and William H. Moore, Jr., "TRACE: Time-Shared Routines for Analysis, Classification and Evaluation," (paper presented at the Spring Joint Computer Conference, 1967); and in Technical Report, pp. 21-22.

IDEA, a second computer program under further CCBS development, allows the analyst to search a data set in an on-line and iterative fashion for decision tree structures which will best explain the outcomes of simulated or actual decision processes. Rather than specifying a hypothetical decision process and testing it against his data, the researcher employs a set of general heuristics which IDEA uses in a search for a range of decision tree structures each of which produces at least a minimum amount of explanation of decision outcomes. The program suggests the "best" tree structures which then may be more fully analyzed; the analyst, however, has the option of rejecting the program's initial suggestions, whereupon the "next best" set will be suggested, or of directing the system to follow a particular structure. A fully interactive FORTRAN version of IDEA currently is operational on the CCBS-PDP-10.<sup>5</sup>

#### Laboratory Studies of Political Behavior

CCBS also pursues a substantive line of inquiry into the behavior of individuals in simulations or more abstract experimental settings of crisis, negotiation and other areas. Hardware and software developments, and the laboratory environment as a whole, add to CCBS's ability to structure and operate gaming and simulation exercises, and to analyze the behavioral data produced by these exercises.

Under an earlier ARPA contract, a series of gaming exercises was conducted using a 1973 Mid-East scenario. Four teams, representing Egypt, Israel, the United States and the Soviet Union, were used in an exploration of the political-military implications of nuclear arms acquisition by Israel. CCBS has employed the General Inquirer content analysis program to analyze the data produced by the simulations. Illustrative of

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<sup>5</sup>IDEA is described in Lawrence I. Press, Miles S. Rogers, and Gerald H. Shure, "An Interactive Technique for the Analysis of Multivariate Data," Behavioral Science, XIV (September, 1969), 364-370; and in Technical Report, pp. 22-23.

findings of the analysis is that the two "superpowers" involved viewed each other in more positive terms than either evaluated its local "client" state; that greater "cohesion" was maintained in the Soviet-UAR alliance than in the U.S. -Israeli one; and that the Soviets perceived a greater threat from Israel than Israel perceived its threat to the Soviet Union. Further data analyses of the 1973 Mid-East game are under consideration, including a test of some hypotheses on the effects of "commitments" in international bargaining.<sup>6</sup> In a further development of the Mid-East game, three of the nations are programmed on the computer, and a U.S. decision-maker interacts with these nations through the computer terminal facility. The scenario for this simulation is a 1976 Mid-East situation in which the U.S. player must balance off his concern for the viability of Israel as a nation with his concern not to become involved in overt hostilities with the Soviets in the Middle-East.

A recent study reports on data derived from a series of eight laboratory studies of negotiation behavior. The negotiation setting consists of a two-party relationship in which a party might either pursue short-term goals through non-cooperation with the other party, or pursue mutual long-run benefit by consistently agreeing to cooperate on the division of benefits between the parties. Continued cooperation of the pair increases the value of the rewards available to them in the future. One of the major research questions answered by analysis of the data pertained to the relationship of "problem difficulty," "rate of agreement" and "history of prior agreements." "Problem difficulty" was defined as the magnitude of possible short-term individual gains in relation to the benefits derived from mutual agreement. Analysis of the experimental data revealed, as expected, that when potential individual gains through non-cooperation were higher than the benefit to the parties through agreement, agreement tended not to occur. However, it also was found that the effects of problem difficulty depended upon the history of prior agreements of the

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<sup>6</sup> Technical Report, pp. 27-30.

pair: agreement on "difficult" problems was made more often by pairs with a past history of agreement than by pairs without such a history.<sup>7</sup>

Further experimental studies of negotiation behavior are planned at CCBS. Simulation-testable hypotheses in other areas, including deterrence theory, also have been developed for testing in the laboratory environment.<sup>8</sup> CCBS laboratory experiments of this type, it is felt, will be enhanced by the continuing effort to develop and improve the hardware and software equipment of the laboratory.

### General Developments

CCBS hardware developments for experimental gaming and simulation provide an environment capable of supporting a wide range of laboratory studies. Multi-person gaming is facilitated by communications equipment including closed-circuit television; computer terminals tied into a central computer allow access to relevant data files during the course of gaming. Variation on the multi-person game is provided by the programmed simulations with which a subject may interact through the computer terminals. The behavior of subjects may be recorded automatically by the main computer and analyzed at a later time. TRACE and IDEA, two sets of programs designed for more powerful and flexible analysis and organization of these types of data, and other data sets, are undergoing further development at CCBS. IDEA is particularly oriented toward the discovery of relationships in decision-making data that are not readily surfaced by other statistical methods. Substantive research on decision processes in crisis and negotiations have yielded findings on the effects of successful cooperation on future negotiation between parties.

For further reference to CCBS research, see the bibliography in Appendix B.

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<sup>7</sup> H. H. Kelly et al., "A Comparative Experimental Study of Negotiation Behavior," Journal of Personality and Social Psychology, XVI (1970), 411-438.

<sup>8</sup> Technical Report, pp. 33-35.

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## APPENDIX B: PROJECT BIBLIOGRAPHIES

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Appendix B contains six bibliographies, one for each of the projects surveyed. Each bibliography consists of two sections: Project Reports and Related Papers. The first category includes papers which were submitted to the funding agency or which were explicitly prepared in support of the funding contract. The second category includes other papers that are closely associated with project work as well as published versions of earlier project reports. When the published version is included in Related Papers, it is not listed in Project Reports.

The Dimensionality of Nations Project  
University of Hawaii  
Principal Investigator: R. J. Rummel

Most Project Reports were prepared in support of Office of Naval Research Contract #N00014-67-A-0387-0003, and many also in support of National Science Foundation Grant No. GS-1230.

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These Project Reports were prepared in support of Rome Air Development Center Contract DAH15-69-C-0347. Each includes short summaries of all programs supported by the Cambridge Project. More detailed papers may be obtained by contacting the principal investigators of the individual projects.

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